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(54) **ZANTEDESCHIA VARIETY GSCCCAFI**

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(57) **ABSTRACT**

Zantedeschia variety designated GSCCCAFI is disclosed. The invention relates to the seeds of *Zantedeschia* GSCCCAFI, to the plants of *Zantedeschia* GSCCCAFI, to plant parts of *Zantedeschia* GSCCCAFI, and to methods for producing a *Zantedeschia* plant produced by crossing *Zantedeschia* GSCCCAFI with itself or with another *Zantedeschia*. The invention also relates to methods for producing a *Zantedeschia* plant containing in its genetic material one or more genes or transgenes and to the transgenic *Zantedeschia* plants and plant parts produced by those methods. This invention also relates to *Zantedeschia* varieties, or breeding varieties, and plant parts derived from *Zantedeschia* GSCCCAFI, to methods for producing other *Zantedeschia* varieties, hybrids, or plant parts derived from *Zantedeschia* GSCCCAFI, and to the *Zantedeschia* plants, varieties, and their parts derived from use of those methods. The invention further relates to hybrid *Zantedeschia* seeds, plants, and plant parts produced by crossing *Zantedeschia* GSCCCAFI with another *Zantedeschia* variety.

13 Claims, No Drawings

ZANTEDESCHIA VARIETY GSCCCAFI**BACKGROUND**

All publications cited in this application are herein incorporated by reference. *Zantedeschia* sp., are members of the Araceae family. *Zantedeschia* are herbaceous flowering plants that are native to Africa. The genus *Zantedeschia* is composed of several species such as the more evergreen, mostly white and cool-season flowering *Z. aethiopica* to the Aestivae colored types such as *Z. albomaculata*, *Z. rehmannii*, *Z. elliotiana*, *Z. pentlandii*, and *Z. jucunda*.

Zantedeschia can be propagated from seed, tubers, and tissue culture. Seed, tuber and tissue culture germination protocols for *Zantedeschia* are well-known in the art.

There are numerous steps in the development of any novel, desirable plant germplasm. Plant breeding begins with the analysis and definition of problems and weaknesses of the current germplasm, the establishment of program goals, and the definition of specific breeding objectives. The next step is selection of germplasm that possesses the traits to meet the program goals. The goal is to combine in a single variety an improved combination of desirable traits from the parental germplasm. These important traits may include higher seed yield, resistance to diseases and insects, better stems and roots, tolerance to drought and heat, and better commercial plant and flower quality.

Zantedeschia is an important and valuable ornamental plant. Thus, a continuing goal of ornamental plant breeders is to develop varieties with novel characteristics, such as color, growth habit, and hardiness. To accomplish this goal, the breeder must select and develop plants that have traits that result in superior *Zantedeschia* varieties.

The foregoing examples of the related art and limitations related therewith are intended to be illustrative and not exclusive. Other limitations of the related art will become apparent to those of skill in the art upon a reading of the specification.

SUMMARY

The following embodiments and aspects thereof are described in conjunction with systems, tools and methods which are meant to be exemplary, not limiting in scope. In various embodiments, one or more of the above-described problems have been reduced or eliminated, while other embodiments are directed to other improvements.

According to one aspect of the invention, there is provided a novel *Zantedeschia* variety designated GSCCCAFI. Plants of *Zantedeschia* are further valued as breeding lines enabling the development of superior ornamental *Zantedeschia* plants having a range of desirable colored spathes and superior growth performance.

In another aspect, the present invention relates to plants, seeds, and other plant parts such as pollen, ovules, embryos, protoplasts, meristematic cells, callus, pollen, leaves, ovules, anthers, cotyledons, hypocotyl, pistils, roots, root tips, spathe, spadix, seeds, petiole, rhizome, pods, berries, bulb, tuber, shoot, or stems of *Zantedeschia* GSCCCAFI or the like.

In another aspect, the present invention relates to plants of *Zantedeschia* GSCCCAFI, and to methods for producing a *Zantedeschia* plant produced by crossing *Zantedeschia* GSCCCAFI with itself or another *Zantedeschia* plant, and the creation of variants by mutagenesis or transformation of *Zantedeschia* GSCCCAFI.

Thus, any such methods using *Zantedeschia* GSCCCAFI are part of this invention: selfing, backcrosses, hybrid production, crosses to populations, and the like. All plants produced

using *Zantedeschia* GSCCCAFI as at least one parent are within the scope of this invention. *Zantedeschia* GSCCCAFI could be used in crosses with other, different, *Zantedeschia* plants to produce first generation (F_1) *Zantedeschia* hybrid seeds and plants with superior characteristics.

In another aspect, the present invention provides for a method of producing a *Zantedeschia* plant comprising crossing a first parent plant with a second parent plant and harvesting the resultant seed, whether either one or both parents are *Zantedeschia* GSCCCAFI.

In another aspect, the present invention provides for single or multiple gene converted plants of *Zantedeschia* GSCCCAFI. The transferred gene(s) may preferably be a dominant or recessive allele. Preferably, the transferred gene(s) will confer such traits as herbicide tolerance, insect resistance, resistance for bacterial, fungal, or viral disease, male fertility, and male sterility. The gene may be a naturally occurring *Zantedeschia* gene or a transgene or gene introduced through genetic engineering techniques.

In another aspect, the present invention provides regenerable cells for use in tissue culture of *Zantedeschia* variety GSCCCAFI. The tissue culture will preferably be capable of regenerating plants having all the physiological and morphological characteristics of the foregoing *Zantedeschia* plant, and of regenerating plants having substantially the same genotype as the foregoing *Zantedeschia* plant. Preferably, the regenerable cells in such tissue cultures will be pollen, ovules, embryos, protoplasts, meristematic cells, callus, pollen, leaves, ovules, anthers, cotyledons, hypocotyl, pistils, roots, root tips, spathe, spadix, seeds, petiole, rhizome, pods, berries, bulb, tuber, shoot, stems or the like. Still further, the present invention provides *Zantedeschia* plants regenerated from the tissue cultures of *Zantedeschia* GSCCCAFI.

In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by study of the following descriptions.

DEFINITIONS

In the description and tables herein, a number of terms are used. In order to provide a clear and consistent understanding of the specification and claims, including the scope to be given such terms, the following definitions are provided:

Allele. Allele is any of one or more alternative forms for a gene, all of which related to one trait or characteristic. In a diploid cell or organism, the two alleles of a given gene occupy corresponding loci on a pair of homologous chromosomes.

Embryo. The embryo is the small plant contained within a mature seed.

F_3 . The " F_3 " symbol denotes a generation resulting from the selfing of the F_2 generation along with selection for type and roguing of off-types. The "F" number is a term commonly used in genetics, and designates the number of the filial generation. The " F_3 " generation denotes the offspring resulting from the selfing or self mating of members of the generation having the next lower "F" number, that is, the " F_2 " generation.

Gene. As used herein, "gene" refers to a segment of nucleic acid. A gene can be introduced into a genome of a species, whether from a different species or from the same species, using transformation or various breeding methods.

Locus. A locus confers one or more traits such as, for example, male sterility, herbicide tolerance, insect resistance, disease resistance, waxy starch, modified fatty acid metabolism, modified phytic acid metabolism, modified carbohydrate metabolism, and modified protein metabolism. The trait

may be, for example, conferred by a naturally occurring gene introduced into the genome of the variety by backcrossing, a natural or induced mutation, or a transgene introduced through genetic transformation techniques. A locus may comprise one or more alleles integrated at a single chromosomal location.

Plant Diameter. Plant diameter is the spread of the plant, is measured at the widest horizontal spread of the plant.

Plant Form. Plant form refers to the silhouette or profile of the plant, ranging from upright to semi-spreading to spreading.

Plant Height. Plant height is taken from the top of the soil to the top of the spathe and is measured in centimeters.

Progeny. As used herein, includes an *F*₁ *Zantedeschia* plant produced from the cross of two *Zantedeschia* plants where at least one plant includes *Zantedeschia* variety GSCCCAFI and progeny further includes, but is not limited to, subsequent *F*₂, *F*₃, *F*₄, *F*₅, *F*₆, *F*₇, *F*₈, *F*₉, and *F*₁₀ generational crosses with the recurrent parental line.

Pubescence. This refers to a covering of very fine hairs closely arranged on the leaves, stems, and pods of the *Zantedeschia* plant.

Quantitative Trait Loci (QTL). Quantitative trait loci (QTL) refer to genetic loci that control to some degree numerically representable traits that are usually continuously distributed.

RHS. RHS refers to the acronym for Royal Horticultural Society that publishes a color chart used in the plant industry. All RHS colors referred to herein are from the RHS 2007 edition.

Single Gene Converted (Conversion). Single gene converted (conversion) plants refers to plants which are developed by a plant breeding technique called backcrossing wherein essentially all of the desired morphological and physiological characteristics of a variety are recovered in addition to the single gene transferred into the variety via the backcrossing technique or via genetic engineering.

Spadix. Spadix refers to a type of spike inflorescence having small flowers borne on a fleshy stem.

Spathe. Spathe refers to the leaf-like bract surrounding the spadix.

DETAILED DESCRIPTION

Zantedeschia variety GSCCCAFI is a semi-spreading plant with yellow-orange spathes having orange-red margins. Some of the selection criteria used for various generations include: Plant form; leaf size, shape, color; maculation presence, shape, and density; petiole length; number of stems (peduncles); determinacy of stem development; stem length and strength; spathe color, size, and shape; spadix color and size; pollen production; seed production; tuber production; resistance to soil pathogens; post-harvest quality (stem strength, stability of spathe color and shape); overall distinctness, uniformity, and stability.

Zantedeschia GSCCCAFI has shown uniformity and stability, as described in the following variety description information.

Zantedeschia GSCCCAFI has the following morphologic and other characteristics (based primarily on data collected at Moss Landing, Calif.). All measurements below are given as median values.

Table 1: Variety Description Information

Plant form: Semi-spreading
Plant height (from top of soil to top of spathe): 13.3 cm

Plant diameter: 30.5 cm

Leaf blade width: 5.75 cm

Leaf blade length: 13.3 cm

Leaf blade shape: Lanceolate

Leaf blade, color of upper surface: RHS 137A

Leaf blade, color of lower surface: RHS 137B

Leaf blade, undulation of margin: Weakly expressed

Attitude of leaf blade: Semi-erect

Leaf blade apex: Acute

Leaf blade, maculation on upper surface: Absent

Petiole length: 10.5 cm

Petiole color: RHS 138C

Spathe height from soil: 29.5 cm

Spathe width: 4.4 cm

Spathe length: 5.5 cm

Spathe color (outer surface): Margins range from RHS 34B to RHS 34A (Orange-Red); the upper and mid-part range from RHS 16A to RHS 17C (Yellow-Orange); and the base is RHS 14B (Yellow-Orange)

Spathe color (inner surface): Margins range from RHS 34B to RHS 34A (Orange-Red); the upper and mid-part range from RHS 16A to RHS 17C (Yellow-Orange); and the base is RHS 14B (Yellow-Orange)

Spathe shape: Trumpet-shaped

Awl-shaped tip: Present

Recurve of spathe: Weak

Spathe wrapping: Strong

Wave of spathe margin: Weak

Fragrance: Absent

Spathe, presence of throat spot: Absent

Spadix length: 2.5 cm

Spadix width: 0.6 cm

Spadix color: RHS 9B (Yellow)

Peduncle length: 23.25 cm

Peduncle color: RHS 138C

Pollen amount: Moderate

Pollen color: RHS 157C (Green-White)

When *Zantedeschia* variety GSCCCAFI is compared to 'Fire Dancer', *Zantedeschia* variety GSCCCAFI has small narrow spathes, and lanceolate-shaped leaves with no maculation, while 'Fire Dancer' has large rounded spathes with cordate-shaped leaves having maculation.

FURTHER EMBODIMENTS

Breeding With *Zantedeschia* Variety GSCCCAFI

The complexity of inheritance influences choice of the breeding method. Backcross breeding is used to transfer one or a few favorable genes for a highly heritable trait into a desirable variety. This approach has been used extensively for breeding disease-resistant varieties. Various recurrent selection techniques are used to improve quantitatively inherited traits controlled by numerous genes. The use of recurrent selection in self-pollinating plants depends on the ease of pollination, the frequency of successful hybrids from each pollination, and the number of hybrid offspring from each successful cross.

Promising advanced breeding lines are thoroughly tested and compared to appropriate standards in environments representative of the commercial target area(s) for three or more years. The best lines are candidates for new commercial varieties; those still deficient in a few traits may be used as parents to produce new populations for further selection.

These processes, which lead to the final step of marketing and distribution, usually take from eight to twelve years from the time the first cross is made. Therefore, development of

new varieties is a time-consuming process that requires precise forward planning, efficient use of resources, and a minimum of changes in direction.

A most difficult task is the identification of individuals that are genetically superior, because for most traits the true genotypic value is masked by other confounding plant traits or environmental factors. One method of identifying a superior plant is to observe its performance relative to other experimental plants and to a widely grown standard variety. If a single observation is inconclusive, replicated observations provide a better estimate of its genetic worth.

The goal of ornamental plant breeding is to develop new, unique and superior ornamental varieties and hybrids. The breeder initially selects and crosses two or more parental lines, followed by repeated selfing and selection, producing many new genetic combinations. The breeder can theoretically generate billions of different genetic combinations via crossing, selection, selfing and mutations. Therefore, a breeder will never develop the same variety, or even very similar varieties, having the same traits from the exact same parents.

Each year, the plant breeder selects the germplasm to advance to the next generation. This germplasm is grown under unique and different geographical, climatic and soil conditions and further selections are then made during and at the end of the growing season. The varieties that are developed are unpredictable because the breeder's selection occurs in unique environments with no control at the DNA level, and with millions of different possible genetic combinations being generated. A breeder of ordinary skill in the art cannot predict the final resulting lines he develops, except possibly in a very gross and general fashion. The same breeder cannot produce the same variety twice by using the same original parents and the same selection techniques. This unpredictability results in the expenditure of large amounts of research monies to develop superior new *Zantedeschia* varieties.

Breeding programs combine desirable traits from two or more varieties or various broad-based sources into breeding pools from which varieties are developed by selfing and selection of desired phenotypes. Pedigree breeding is used commonly for the improvement of self-pollinating plants. Two parents that possess favorable, complementary traits are crossed to produce an F_1 . An F_2 population is produced by selfing one or several F_1 s. Selection of the best individuals may begin in the F_2 population; then, beginning in the F_3 , the best individuals in the best families are selected. Replicated testing of families can begin in the F_4 generation to improve the effectiveness of selection for traits with low heritability. At an advanced stage of inbreeding (i.e., F_6 and F_7), the best lines or mixtures of phenotypically similar lines are tested for potential release as new varieties.

Using *Zantedeschia* Variety GSCCCAFI to Develop Other *Zantedeschia* Varieties

Zantedeschia varieties such as *Zantedeschia* variety GSCCCAFI are developed for sales in the ornamental and cut flower market. However, *Zantedeschia* varieties such as *Zantedeschia* variety GSCCCAFI also provide a source of breeding material that may be used to develop new *Zantedeschia* varieties. Plant breeding techniques known in the art and used in a *Zantedeschia* plant breeding program include, but are not limited to, recurrent selection, mass selection, bulk selection, hybridization, mass selection, backcrossing, pedigree breeding, open-pollination breeding, restriction fragment length polymorphism enhanced selection, genetic marker enhanced selection, making double haploids, mutagenesis and transformation. Often combinations of these techniques are used. The development of *Zantedeschia* varieties in a plant breeding

program requires, in general, the development and evaluation of homozygous varieties. There are many analytical methods available to evaluate a new variety. The oldest and most traditional method of analysis is the observation of phenotypic traits, but genotypic analysis may also be used.

Additional Breeding Methods

One embodiment of the present invention is directed to methods for producing a *Zantedeschia* plant by crossing a first parent *Zantedeschia* plant with a second parent *Zantedeschia* plant, wherein the first or second *Zantedeschia* plant is the *Zantedeschia* plant from *Zantedeschia* variety GSCCCAFI. Further, both first and second parent *Zantedeschia* plants may be from *Zantedeschia* variety GSCCCAFI. Therefore, any methods using *Zantedeschia* variety GSCCCAFI are an embodiment of this invention, such as selfing, backcrosses, hybrid breeding, and crosses to populations. Any plants produced using *Zantedeschia* variety GSCCCAFI as at least one parent are also an embodiment of the invention. These methods are well-known in the art and some of the more commonly used breeding methods are described herein. Descriptions of breeding methods can be found in one of several reference books (e.g., Allard, "Principles of Plant Breeding" (1960); and Fehr, "Breeding Methods for Cultivar Development," 2nd ed., Wilcox editor (1987)).

The following describes breeding methods that may be used with *Zantedeschia* variety GSCCCAFI in the development of further *Zantedeschia* plants. One such embodiment is a method for developing a *Zantedeschia* GSCCCAFI progeny plant in a *Zantedeschia* plant breeding program comprising: obtaining the *Zantedeschia* plant, or a part thereof, of *Zantedeschia* variety GSCCCAFI, utilizing said plant, or plant part, as a source of breeding material, and selecting a *Zantedeschia* variety GSCCCAFI progeny plant with molecular markers in common with *Zantedeschia* variety GSCCCAFI and/or with morphological and/or physiological characteristics selected from the characteristics listed in Table 1. Breeding steps that may be used in the *Zantedeschia* plant breeding program can include for example, pedigree breeding, backcrossing, mutation breeding, and recurrent selection. In conjunction with these steps, techniques such as RFLP-enhanced selection, genetic marker enhanced selection (for example, SSR markers), and the making of double haploids may be utilized.

Another method involves producing a population of *Zantedeschia* variety GSCCCAFI progeny *Zantedeschia* plants, comprising crossing *Zantedeschia* variety GSCCCAFI with another *Zantedeschia* plant, thereby producing a population of *Zantedeschia* plants which, on average, derive 50% of their alleles from *Zantedeschia* variety GSCCCAFI. A plant of this population may be selected and repeatedly selfed or sibbed with a *Zantedeschia* variety resulting from these successive filial generations. One embodiment of this invention is the *Zantedeschia* variety produced by this method and that has obtained at least 50% of its alleles from *Zantedeschia* variety GSCCCAFI.

One of ordinary skill in the art of plant breeding would know how to evaluate the traits of two plant varieties to determine if there is no significant difference between the two traits expressed by those varieties. For example, see, Fehr and Walt, Principles of Cultivar Development, pp. 261-286 (1987). Thus, the invention includes *Zantedeschia* variety GSCCCAFI progeny *Zantedeschia* plants comprising a combination of at least two *Zantedeschia* variety GSCCCAFI traits selected from the group consisting of those listed in Table 1 or *Zantedeschia* variety GSCCCAFI combination of traits listed in the Summary, so that said progeny *Zantedeschia* plant is not significantly different for said traits than

Zantedeschia variety GSCCCAFI as determined at the 5% significance level when grown in the same environmental conditions. Using techniques described herein, molecular markers may be used to identify said progeny plant as a *Zantedeschia* variety GSCCCAFI progeny plant. Mean trait values may be used to determine whether trait differences are significant, and preferably the traits are measured on plants grown under the same environmental conditions. Once such a variety is developed, its value is substantial since it is important to advance the germplasm base as a whole in order to maintain or improve traits such as ornamental features, disease resistance, pest resistance, and plant performance in extreme environmental conditions.

Progeny of *Zantedeschia* variety GSCCCAFI may also be characterized through their filial relationship with *Zantedeschia* variety GSCCCAFI, as for example, being within a certain number of breeding crosses of *Zantedeschia* variety GSCCCAFI. A breeding cross is a cross made to introduce new genetics into the progeny, and is distinguished from a cross, such as a self or a sib cross, made to select among existing genetic alleles. The lower the number of breeding crosses in the pedigree, the closer the relationship between *Zantedeschia* variety GSCCCAFI and its progeny. For example, progeny produced by the methods described herein may be within 1, 2, 3, 4, or 5 breeding crosses of *Zantedeschia* variety GSCCCAFI.

As used herein, the term "plant" includes plant cells, plant protoplasts, plant cell tissue cultures from which *Zantedeschia* plants can be regenerated, plant calli, plant clumps, and plant cells that are intact in plants or parts of plants, such as pollen, ovules, embryos, protoplasts, meristematic cells, callus, pollen, leaves, ovules, anthers, cotyledons, hypocotyl, pistils, roots, root tips, spathe, spadix, seeds, petiole, rhizome, pods, berries, bulb, tuber, shoot, or stems and the like.

Pedigree Breeding

Pedigree breeding starts with the crossing of two genotypes, such as *Zantedeschia* GSCCCAFI and another *Zantedeschia* variety having one or more desirable characteristics that is lacking or which complements *Zantedeschia* variety GSCCCAFI. If the two original parents do not provide all the desired characteristics, other sources can be included in the breeding population. In the pedigree method, superior plants are selfed and selected in successive filial generations. In the succeeding filial generations, the heterozygous condition gives way to homogeneous varieties as a result of self-pollination and selection. Typically in the pedigree method of breeding, five or more successive filial generations of selfing and selection is practiced: F_1 to F_2 ; F_2 to F_3 ; F_3 to F_4 ; F_4 to F_5 ; etc. After a sufficient amount of inbreeding, successive filial generations will serve to increase seed of the developed variety. Preferably, the developed variety comprises homozygous alleles at about 95% or more of its loci.

Backcross Breeding

Backcross breeding has been used to transfer genes for a simply inherited, highly heritable trait into a desirable homozygous variety or inbred line which is the recurrent parent. The source of the trait to be transferred is called the donor parent. After the initial cross, individuals possessing the phenotype of the donor parent are selected and repeatedly crossed (backcrossed) to the recurrent parent. The resulting plant is expected to have the attributes of the recurrent parent and the desirable trait transferred from the donor parent.

In addition to being used to create a backcross conversion, backcrossing can also be used in combination with pedigree breeding. As discussed previously, backcrossing can be used to transfer one or more specifically desirable traits from one variety, the donor parent, to a developed variety called the

recurrent parent, which has overall good commercial characteristics yet lacks that desirable trait or traits. However, the same procedure can be used to move the progeny toward the genotype of the recurrent parent, but at the same time retain many components of the nonrecurrent parent by stopping the backcrossing at an early stage and proceeding with selfing and selection. For example, a *Zantedeschia* variety may be crossed with another variety to produce a first generation progeny plant. The first generation progeny plant may then be backcrossed to one of its parent varieties to create a BC_1 or BC_2 . Progeny are selfed and selected so that the newly developed variety has many of the attributes of the recurrent parent and yet several of the desired attributes of the nonrecurrent parent. This approach leverages the value and strengths of the recurrent parent for use in new *Zantedeschia* varieties.

Therefore, an embodiment of this invention is a method of making a backcross conversion of *Zantedeschia* variety GSCCCAFI, comprising the steps of crossing a plant of *Zantedeschia* variety GSCCCAFI with a donor plant comprising a desired trait, selecting an F_1 progeny plant comprising the desired trait, and backcrossing the selected F_1 progeny plant to a plant of *Zantedeschia* variety GSCCCAFI. This method may further comprise the step of obtaining a molecular marker profile of *Zantedeschia* variety GSCCCAFI and using the molecular marker profile to select for a progeny plant with the desired trait and the molecular marker profile of *Zantedeschia* variety GSCCCAFI. In one embodiment, the desired trait is a mutant gene, gene, or transgene present in the donor parent.

Recurrent Selection and Mass Selection

Recurrent selection is a method used in a plant breeding program to improve a population of plants. *Zantedeschia* variety GSCCCAFI is suitable for use in a recurrent selection program. The method entails individual plants cross-pollinating with each other to form progeny. The progeny are grown and the superior progeny selected by any number of selection methods, which include individual plant, half-sib progeny, full-sib progeny, and selfed progeny. The selected progeny are cross-pollinated with each other to form progeny for another population. This population is planted and again superior plants are selected to cross-pollinate with each other. Recurrent selection is a cyclical process and therefore can be repeated as many times as desired. The objective of recurrent selection is to improve the traits of a population. The improved population can then be used as a source of breeding material to obtain new varieties for commercial or breeding use, including the production of a synthetic variety. A synthetic variety is the resultant progeny formed by the intercrossing of several selected varieties.

Mass selection is a useful technique when used in conjunction with molecular marker enhanced selection. In mass selection, seeds from individuals are selected based on phenotype or genotype. These selected seeds are then bulked and used to grow the next generation. Bulk selection requires growing a population of plants in a bulk plot, allowing the plants to self-pollinate, harvesting the seed in bulk, and then using a sample of the seed harvested in bulk to plant the next generation. Also, instead of self-pollination, directed pollination could be used as part of the breeding program.

Mass and recurrent selections can be used to improve populations of either self- or cross-pollinating plants. A genetically variable population of heterozygous individuals is either identified, or created, by intercrossing several different parents. The best plants are selected based on individual superiority, outstanding progeny, or excellent combining ability. The selected plants are intercrossed to produce a new population in which further cycles of selection are continued.

Mutation Breeding

Mutation breeding is another method of introducing new traits into *Zantedeschia* variety GSCCCAFI. Mutations that occur spontaneously or are artificially induced can be useful sources of variability for a plant breeder. The goal of artificial mutagenesis is to increase the rate of mutation for a desired characteristic. Mutation rates can be increased by many different means including temperature, long-term seed storage, tissue culture conditions, radiation; such as X-rays, Gamma rays (e.g., cobalt 60 or cesium 137), neutrons, (product of nuclear fission by uranium 235 in an atomic reactor), Beta radiation (emitted from radioisotopes such as phosphorus 32 or carbon 14), or ultraviolet radiation (preferably from 2500 to 2900 nm), or chemical mutagens (such as base analogues (5-bromo-uracil)), related compounds (8-ethoxy caffeine), antibiotics (streptomycin), alkylating agents (sulfur mustards, nitrogen mustards, epoxides, ethylenamines, sulfates, sulfonates, sulfones, lactones), azide, hydroxylamine, nitrous acid, or acridines. Once a desired trait is observed through mutagenesis the trait may then be incorporated into existing germplasm by traditional breeding techniques. Details of mutation breeding can be found in Fehr, "Principles of Cultivar Development," Macmillan Publishing Company (1993). In addition, mutations created in other *Zantedeschia* plants may be used to produce a backcross conversion of *Zantedeschia* variety GSCCCAFI that comprises such mutation.

Additional methods include, but are not limited to, expression vectors introduced into plant tissues using a direct gene transfer method, such as microprojectile-mediated delivery, DNA injection, electroporation, and the like. More preferably, expression vectors are introduced into plant tissues by using either microprojectile-mediated delivery with a biolistic device or by using *Agrobacterium*-mediated transformation. Transformant plants obtained with the protoplasm of the invention are intended to be within the scope of this invention. Single-Gene Conversions

When the term *Zantedeschia* plant is used in the context of an embodiment of the present invention, this also includes any single gene conversions of that variety. The term single gene converted plant as used herein refers to those *Zantedeschia* plants which are developed by a plant breeding technique called backcrossing wherein essentially all of the desired morphological and physiological characteristics of a variety are recovered in addition to the single gene transferred into the variety via the backcrossing technique. Backcrossing methods can be used with one embodiment of the present invention to improve or introduce a characteristic into the variety. The term "backcrossing" as used herein refers to the repeated crossing of a hybrid progeny back to the recurrent parent, i.e., backcrossing 1, 2, 3, 4, 5, 6, 7, 8, or more times to the recurrent parent. The parental *Zantedeschia* plant that contributes the gene for the desired characteristic is termed the nonrecurrent or donor parent. This terminology refers to the fact that the nonrecurrent parent is used one time in the backcross protocol and therefore does not recur. The parental *Zantedeschia* plant to which the gene or genes from the non-recurrent parent are transferred is known as the recurrent parent as it is used for several rounds in the backcrossing protocol (Poehlman & Sleper (1994); Fehr, Principles of Cultivar Development, pp. 261-286 (1987)). In a typical backcross protocol, the original variety of interest (recurrent parent) is crossed to a second variety (nonrecurrent parent) that carries the single gene of interest to be transferred. The resulting progeny from this cross are then crossed again to the recurrent parent and the process is repeated until a *Zantedeschia* plant is obtained wherein essentially all of the desired morphological and physiological characteristics of the recur-

rent parent are recovered in the converted plant, in addition to the single transferred gene from the nonrecurrent parent.

The selection of a suitable recurrent parent is an important step for a successful backcrossing procedure. The goal of a backcross protocol is to alter or substitute a single trait or characteristic in the original variety. To accomplish this, a single gene of the recurrent variety is modified or substituted with the desired gene from the nonrecurrent parent, while retaining essentially all of the rest of the desired genetic, and therefore the desired physiological and morphological constitution of the original variety. The choice of the particular nonrecurrent parent will depend on the purpose of the backcross; one of the major purposes is to add some commercially important trait or traits to the plant. The exact backcrossing protocol will depend on the characteristic or trait being altered to determine an appropriate testing protocol. Although backcrossing methods are simplified when the characteristic being transferred is a dominant allele, a recessive allele may also be transferred. In this instance it may be necessary to introduce a test of the progeny to determine if the desired characteristic has been successfully transferred.

Many single gene traits have been identified that are not regularly selected for in the development of a new variety but that can be improved by backcrossing techniques. Single gene traits may or may not be transgenic. Examples of these traits include, but are not limited to, male sterility, waxy starch, herbicide resistance, resistance for bacterial, fungal, or viral disease, insect resistance, male fertility, and commercial characteristics such as flower color. These genes are generally inherited through the nucleus. Several of these single gene traits are described in U.S. Pat. Nos. 5,959,185, 5,973,234, 5,977,445, and 6,080,920, the disclosures of which are specifically hereby incorporated by reference. Introduction of a New Trait or Locus into *Zantedeschia* Variety GSCCCAFI

Zantedeschia variety GSCCCAFI represents a new base genetic variety into which a new locus or trait may be introgressed. Direct transformation and backcrossing represent two important methods that can be used to accomplish such an introgression. The term backcross conversion and single locus conversion are used interchangeably to designate the product of a backcrossing program.

Backcross Conversions of *Zantedeschia* Variety GSCCCAFI

A backcross conversion of *Zantedeschia* variety GSCCCAFI occurs when DNA sequences are introduced through backcrossing (Allard, "Principles of Plant Breeding" (1960); and Fehr, "Breeding Methods for Cultivar Development," 2nd ed., Wilcox editor (1987)) with *Zantedeschia* variety GSCCCAFI utilized as the recurrent parent. Both naturally occurring and transgenic DNA sequences may be introduced through backcrossing techniques. A backcross conversion may produce a plant with a trait or locus conversion in at least two or more backcrosses, including at least 2 crosses, at least 3 crosses, at least 4 crosses, at least 5 crosses, and the like. Molecular marker assisted breeding or selection may be utilized to reduce the number of backcrosses necessary to achieve the backcross conversion. For example, see, Openshaw, S. J., et al., Marker-assisted Selection in Backcross Breeding, Proceedings Symposium of the Analysis of Molecular Data, Crop Science Society of America, Corvallis, Oreg. (August 1994), where it is demonstrated that a backcross conversion can be made in as few as two backcrosses.

The complexity of the backcross conversion method depends on the type of trait being transferred (single genes or closely linked genes as compared to unlinked genes), the level of expression of the trait, the type of inheritance (cytoplasmic or nuclear), and the types of parents included in the cross. It is

understood by those of ordinary skill in the art that for single gene traits that are relatively easy to classify, the backcross method is effective and relatively easy to manage. (See, Allard, "Principles of Plant Breeding" (1960); and Fehr, "Breeding Methods for Cultivar Development," 2nd ed., Wilcox editor (1987)). Desired traits that may be transferred through backcross conversion include, but are not limited to, sterility (nuclear and cytoplasmic), fertility restoration, drought tolerance, nitrogen utilization, ornamental features, disease resistance (bacterial, fungal, or viral), insect resistance, and herbicide resistance. In addition, an introgression site itself, such as an FRT site, Lox site, or other site specific integration site, may be inserted by backcrossing and utilized for direct insertion of one or more genes of interest into a specific plant variety. In some embodiments of the invention, the number of loci that may be backcrossed into *Zantedeschia* variety GSCCCAFI is at least 1, 2, 3, 4, or 5, and/or no more than 6, 5, 4, 3, or 2. A single locus may contain several transgenes, such as a transgene for disease resistance that, in the same expression vector, also contains a transgene for herbicide resistance. The gene for herbicide resistance may be used as a selectable marker and/or as a phenotypic trait. A single locus conversion of site specific integration system allows for the integration of multiple genes at the converted loci.

The backcross conversion may result from either the transfer of a dominant allele or a recessive allele. Selection of progeny containing the trait of interest is accomplished by direct selection for a trait associated with a dominant allele. Transgenes or genes transferred via backcrossing typically function as a dominant single gene trait and are relatively easy to classify. Selection of progeny for a trait that is transferred via a recessive allele requires growing and selfing the first backcross generation to determine which plants carry the recessive alleles. Recessive traits may require additional progeny testing in successive backcross generations to determine the presence of the locus of interest. The last backcross generation is usually selfed to give pure breeding progeny for the gene(s) being transferred, although a backcross conversion with a stably introgressed trait may also be maintained by further backcrossing to the recurrent parent with selection for the converted trait.

Along with selection for the trait of interest, progeny are selected for the phenotype of the recurrent parent. The backcross is a form of inbreeding, and the features of the recurrent parent are automatically recovered after successive backcrosses. Poehlman, *Breeding Field Crops*, p. 204 (1987). Poehlman suggests from one to four or more backcrosses, but as noted above, the number of backcrosses necessary can be reduced with the use of molecular markers. Other factors, such as a genetically similar donor parent, may also reduce the number of backcrosses necessary. As noted by Poehlman, backcrossing is easiest for simply inherited, dominant, and easily recognized traits.

One process for adding or modifying a trait or locus in *Zantedeschia* variety GSCCCAFI comprises crossing *Zantedeschia* variety GSCCCAFI plants grown from *Zantedeschia* variety GSCCCAFI seed with plants of another *Zantedeschia* variety that comprise the desired trait or locus, selecting F₁ progeny plants that comprise the desired trait or locus to produce selected F₁ progeny plants, crossing the selected progeny plants with *Zantedeschia* variety GSCCCAFI plants to produce backcross progeny plants, selecting for backcross progeny plants that have the desired trait or locus and the morphological characteristics of *Zantedeschia* variety GSCCCAFI to produce selected backcross progeny plants, and backcrossing to *Zantedeschia* variety GSCCCAFI

three or more times in succession to produce selected fourth or higher backcross progeny plants that comprise said trait or locus. The modified *Zantedeschia* variety GSCCCAFI may be further characterized as having the physiological and morphological characteristics of *Zantedeschia* variety GSCCCAFI listed in Table 1 as determined at the 5% significance level when grown in the same environmental conditions and/or may be characterized by percent similarity or identity to *Zantedeschia* variety GSCCCAFI as determined by SSR markers. The above method may be utilized with fewer backcrosses in appropriate situations, such as when the donor parent is highly related or markers are used in the selection step. Desired traits that may be used include those nucleic acids known in the art, some of which are listed herein, that will affect traits through nucleic acid expression or inhibition. Desired loci include the introgression of FRT, Lox, and other sites for site specific integration, which may also affect a desired trait if a functional nucleic acid is inserted at the integration site.

In addition, the above process and other similar processes described herein may be used to produce first generation progeny *Zantedeschia* seed by adding a step at the end of the process that comprises crossing *Zantedeschia* variety GSCCCAFI with the introgressed trait or locus with a different *Zantedeschia* plant and harvesting the resultant first generation progeny *Zantedeschia* seed.

Molecular Techniques Using *Zantedeschia* Variety GSCCCAFI

The advent of new molecular biological techniques has allowed the isolation and characterization of genetic elements with specific functions, such as encoding specific protein products. Scientists in the field of plant biology developed a strong interest in engineering the genome of plants to contain and express foreign genetic elements, or additional, or modified versions of native or endogenous genetic elements in order to "alter" (the utilization of up-regulation, down-regulation, or gene silencing) the traits of a plant in a specific manner. Any DNA sequences, whether from a different species or from the same species, which are introduced into the genome using transformation or various breeding methods are referred to herein collectively as "transgenes." In some embodiments of the invention, a transgenic variant of *Zantedeschia* variety GSCCCAFI may contain at least one transgene but could contain at least 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and/or no more than 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, or 2. Over the last fifteen to twenty years several methods for producing transgenic plants have been developed, and another embodiment of the present invention also relates to transgenic variants of *Zantedeschia* variety GSCCCAFI.

Nucleic acids or polynucleotides refer to RNA or DNA that is linear or branched, single or double stranded, or a hybrid thereof. The term also encompasses RNA/DNA hybrids. These terms also encompass untranslated sequence located at both the 3' and 5' ends of the coding region of the gene: at least about 1000 nucleotides of sequence upstream from the 5' end of the coding region and at least about 200 nucleotides of sequence downstream from the 3' end of the coding region of the gene. Less common bases, such as inosine, 5-methylcytosine, 6-methyladenine, hypoxanthine and others can also be used for antisense, dsRNA and ribozyme pairing. For example, polynucleotides that contain C-5 propyne analogues of uridine and cytidine have been shown to bind RNA with high affinity and to be potent antisense inhibitors of gene expression. Other modifications, such as modification to the phosphodiester backbone, or the 2'-hydroxy in the ribose sugar group of the RNA can also be made. The antisense polynucleotides and ribozymes can consist entirely of ribo-

nucleotides, or can contain mixed ribonucleotides and deoxyribonucleotides. The polynucleotides of the invention may be produced by any means, including genomic preparations, cDNA preparations, in-vitro synthesis, RT-PCR, and in-vitro or in-vivo transcription.

One embodiment of the invention is a process for producing *Zantedeschia* variety GSCCAFI further comprising a desired trait, said process comprising introducing a transgene that confers a desired trait to a *Zantedeschia* plant of variety GSCCAFI. Another embodiment is the product produced by this process. In one embodiment the desired trait may be one or more of herbicide resistance, insect resistance, or disease resistance. The specific gene may be any known in the art or listed herein, including a polynucleotide conferring resistance to imidazolinone, dicamba, sulfonylurea, glyphosate, glufosinate, triazine, benzonitrile, cyclohexanedione, phenoxy propionic acid, and L-phosphinothricin; a polynucleotide encoding a *Bacillus thuringiensis* polypeptide; or disease resistance to bacterial soft rot.

Numerous methods for plant transformation have been developed, including biological and physical plant transformation protocols. See, for example, Miki et al., "Procedures for Introducing Foreign DNA into Plants," in *Methods in Plant Molecular Biology and Biotechnology*, and Glick and Thompson Eds., CRC Press, Inc., Boca Raton, pp. 67-88 (1993). In addition, expression vectors and in vitro culture methods for plant cell or tissue transformation and regeneration of plants are available. See, for example, Gruber, et al., "Vectors for Plant Transformation," in *Methods in Plant Molecular Biology and Biotechnology*, Glick and Thompson Eds., CRC Press, Inc., Boca Raton, pp. 89-119 (1993).

A genetic trait which has been engineered into the genome of a particular *Zantedeschia* plant may then be moved into the genome of another variety using traditional breeding techniques that are well known in the plant breeding arts. For example, a backcrossing approach is commonly used to move a transgene from a transformed *Zantedeschia* variety into an already developed *Zantedeschia* variety, and the resulting backcross conversion plant would then comprise the transgene(s).

Various genetic elements can be introduced into the plant genome using transformation. These elements include, but are not limited to, genes, coding sequences, inducible, constitutive and tissue specific promoters, enhancing sequences, and signal and targeting sequences. For example, see the traits, genes, and transformation methods listed in U.S. Pat. No. 6,118,055.

Breeding with Molecular Markers

Molecular markers, which includes markers identified through the use of techniques such as Isozyme Electrophoresis, Restriction Fragment Length Polymorphisms (RFLPs), Randomly Amplified Polymorphic DNAs (RAPDs), Arbitrarily Primed Polymerase Chain Reaction (AP-PCR), DNA Amplification Fingerprinting (DAF), Sequence Characterized Amplified Regions (SCARs), Amplified Fragment Length Polymorphisms (AFLPs), Simple Sequence Repeats (SSRs), and Single Nucleotide Polymorphisms (SNPs), may be used in plant breeding methods utilizing *Zantedeschia* variety GSCCAFI.

Isozyme electrophoresis and RFLPs have been widely used to determine genetic composition. See R. L. Phillips and I. K. Vasil (ed.), *DNA-based markers in plants*, Kluwer Academic Press Dordrecht, the Netherlands.

SSR technology is currently the most efficient and practical marker technology. More marker loci can be routinely used, and more alleles per marker locus can be found, using SSRs in comparison to RFLPs. See for example, Wills, D. M. et al.,

Theoretical and Applied Genetics 110: 941-947 (2005). Single Nucleotide Polymorphisms may also be used to identify the unique genetic composition of the invention and progeny varieties retaining that unique genetic composition. Various molecular marker techniques may be used in combination to enhance overall resolution.

One use of molecular markers is Quantitative Trait Loci (QTL) mapping. QTL mapping is the use of markers, which are known to be closely linked to alleles that have measurable effects on a quantitative trait. Selection in the breeding process is based upon the accumulation of markers linked to the positive effecting alleles and/or the elimination of the markers linked to the negative effecting alleles from the plant's genome.

Molecular markers can also be used during the breeding process for the selection of qualitative traits. For example, markers closely linked to alleles or markers containing sequences within the actual alleles of interest can be used to select plants that contain the alleles of interest during a backcrossing breeding program. The markers can also be used to select for the genome of the recurrent parent and against the genome of the donor parent. Using this procedure can minimize the amount of genome from the donor parent that remains in the selected plants. It can also be used to reduce the number of crosses back to the recurrent parent needed in a backcrossing program. The use of molecular markers in the selection process is often called genetic marker enhanced selection. Molecular markers may also be used to identify and exclude certain sources of germplasm as parental varieties or ancestors of a plant by providing a means of tracking genetic profiles through crosses.

Expression Vectors for *Zantedeschia* Transformation: Marker Genes

Plant transformation involves the construction of an expression vector which will function in plant cells. Such a vector comprises DNA comprising a gene under control of, or operatively linked to, a regulatory element (for example, a promoter). Expression vectors include at least one genetic marker operably linked to a regulatory element (for example, a promoter) that allows transformed cells containing the marker to be either recovered by negative selection, i.e., inhibiting growth of cells that do not contain the selectable marker gene, or by positive selection, i.e., screening for the product encoded by the genetic marker. Many commonly used selectable marker genes for plant transformation are well-known in the transformation arts, and include, for example, genes that code for enzymes that metabolically detoxify a selective chemical agent which may be an antibiotic or an herbicide, or genes that encode an altered target which is insensitive to the inhibitor. A few positive selection methods are also known in the art.

One commonly used selectable marker gene for plant transformation is the neomycin phosphotransferase II (nptII) gene which, when under the control of plant regulatory signals, confers resistance to kanamycin. Fraley, et al., *Proc. Natl. Acad. Sci. USA*, 80:4803 (1983).

Another commonly used selectable marker gene is the hygromycin phosphotransferase gene which confers resistance to the antibiotic hygromycin. Vanden Elzen, et al., *Plant Mol. Biol.*, 5:299 (1985).

Additional selectable marker genes of bacterial origin that confer resistance to antibiotics include gentamycin acetyl transferase, streptomycin phosphotransferase and aminoglycoside-3'-adenyl transferase, the bleomycin resistance determinant (Hayford, et al., *Plant Physiol.*, 86:1216 (1988); Jones, et al., *Mol. Gen. Genet.*, 210:86 (1987); Svab, et al., *Plant Mol. Biol.*, 14:197 (1990); Hille, et al., *Plant Mol. Biol.*,

7:171 (1986)). Other selectable marker genes confer resistance to herbicides such as glyphosate, glufosinate, or bromoxynil (Comai, et al., *Nature*, 317:741-744 (1985); Gordon-Kamm, et al., *Plant Cell*, 2:603-618 (1990); Stalker, et al., *Science*, 242:419-423 (1988)).

Selectable marker genes for plant transformation not of bacterial origin include, for example, mouse dihydrofolate reductase, plant 5-enolpyruvylshikimate-3-phosphate synthase, and plant acetolactate synthase (Eichholtz, et al., *Somatic Cell Mol. Genet.*, 13:67 (1987); Shah, et al., *Science*, 233:478 (1986); Charest, et al., *Plant Cell Rep.*, 8:643 (1990)).

Another class of marker genes for plant transformation requires screening of presumptively transformed plant cells, rather than direct genetic selection of transformed cells, for resistance to a toxic substance such as an antibiotic. These genes are particularly useful to quantify or visualize the spatial pattern of expression of a gene in specific tissues and are frequently referred to as reporter genes because they can be fused to a gene or gene regulatory sequence for the investigation of gene expression. Commonly used genes for screening presumptively transformed cells include β -glucuronidase (GUS), β -galactosidase, luciferase, and chloramphenicol acetyltransferase (Jefferson, R. A., *Plant Mol. Biol. Rep.*, 5:387 (1987); Teeri, et al., *EMBO J.*, 8:343 (1989); Koncz, et al., *Proc. Natl. Acad. Sci. USA*, 84:131 (1987); DeBlock, et al., *EMBO J.*, 3:1681 (1984)).

In-vivo methods for visualizing GUS activity that do not require destruction of plant tissue are available (Molecular Probes, Publication 2908, IMAGENE GREEN, pp. 1-4 (1993); Naleway, et al., *J. Cell Biol.*, 115:151a (1991)). However, these in-vivo methods for visualizing GUS activity have not proven useful for recovery of transformed cells because of low sensitivity, high fluorescent backgrounds, and limitations associated with the use of luciferase genes as selectable markers.

More recently, a gene encoding Green Fluorescent Protein (GFP) has been utilized as a marker for gene expression in prokaryotic and eukaryotic cells (Chalfie, et al., *Science*, 263:802 (1994)). GFP and mutants of GFP may be used as screenable markers.

Expression Vectors for *Zantedeschia* Transformation: Promoters

Genes included in expression vectors must be driven by a nucleotide sequence comprising a regulatory element (for example, a promoter). Several types of promoters are well known in the transformation arts as are other regulatory elements that can be used alone or in combination with promoters.

As used herein, "promoter" includes reference to a region of DNA upstream from the start of transcription and involved in recognition and binding of RNA polymerase and other proteins to initiate transcription. A "plant promoter" is a promoter capable of initiating transcription in plant cells. Examples of promoters under developmental control include promoters that preferentially initiate transcription in certain tissues, such as leaves, roots, seeds, tubers, rhizome, xylem vessels, tracheids, or sclerenchyma. Such promoters are referred to as "tissue-preferred." Promoters that initiate transcription only in a certain tissue are referred to as "tissue-specific." A "cell-type" specific promoter primarily drives expression in certain cell types in one or more organs, for example, vascular cells in roots or leaves. An "inducible" promoter is a promoter which is under environmental control. Examples of environmental conditions that may effect transcription by inducible promoters include anaerobic conditions or the presence of light. Tissue-specific, tissue-pre-

ferred, cell-type specific, and inducible promoters constitute the class of "non-constitutive" promoters. A "constitutive" promoter is a promoter that is active under most environmental conditions.

A. Inducible Promoters: An inducible promoter is operably linked to a gene for expression in *Zantedeschia*. Optionally, the inducible promoter is operably linked to a nucleotide sequence encoding a signal sequence which is operably linked to a gene for expression in *Zantedeschia*. With an inducible promoter the rate of transcription increases in response to an inducing agent.

Any inducible promoter can be used in the instant invention. See, Ward, et al., *Plant Mol. Biol.*, 22:361-366 (1993). Exemplary inducible promoters include, but are not limited to, that from the ACEI system which responds to copper (Mett, et al., *Proc. Natl. Acad. Sci. USA*, 90:4567-4571 (1993)); In2 gene from maize which responds to benzene-sulfonamide herbicide safeners (Hershey, et al., *Mol. Gen. Genetics*, 227:229-237 (1991); Gatz, et al., *Mol. Gen. Genetics*, 243:32-38 (1994)); or Tet repressor from Tn10 (Gatz, et al., *Mol. Gen. Genetics*, 227:229-237 (1991)). A particularly preferred inducible promoter is a promoter that responds to an inducing agent to which plants do not normally respond. An exemplary inducible promoter is the inducible promoter from a steroid hormone gene, the transcriptional activity of which is induced by a glucocorticosteroid hormone (Skena, et al., *Proc. Natl. Acad. Sci. USA*, 88:0421 (1991)).

B. Constitutive Promoters: A constitutive promoter is operably linked to a gene for expression in *Zantedeschia* or the constitutive promoter is operably linked to a nucleotide sequence encoding a signal sequence which is operably linked to a gene for expression in *Zantedeschia*.

Many different constitutive promoters can be utilized in the instant invention. Exemplary constitutive promoters include, but are not limited to, the promoters from plant viruses such as the 35S promoter from CaMV (Odell, et al., *Nature*, 313:810-812 (1985)) and the promoters from such genes as rice actin (McElroy, et al., *Plant Cell*, 2:163-171 (1990)); ubiquitin (Christensen, et al., *Plant Mol. Biol.*, 12:619-632 (1989); Christensen, et al., *Plant Mol. Biol.*, 18:675-689 (1992)); pEMU (Last, et al., *Theor. Appl. Genet.*, 81:581-588 (1991)); MAS (Velten, et al., *EMBO J.*, 3:2723-2730 (1984)); and maize H3 histone (Lepetit, et al., *Mol. Gen. Genetics*, 231:276-285 (1992); Atanassova, et al., *Plant Journal*, 2 (3):291-300 (1992)). The ALS promoter, XbaI/NcoI fragment 5' to the *Brassica napus* ALS3 structural gene (or a nucleotide sequence similarity to said XbaI/NcoI fragment), represents a particularly useful constitutive promoter. See, U.S. Pat. No. 5,659,026.

C. Tissue-Specific or Tissue-Preferred Promoters: A tissue-specific promoter is operably linked to a gene for expression in *Zantedeschia*. Optionally, the tissue-specific promoter is operably linked to a nucleotide sequence encoding a signal sequence which is operably linked to a gene for expression in *Zantedeschia*. Plants transformed with a gene of interest operably linked to a tissue-specific promoter produce the protein product of the transgene exclusively, or preferentially, in a specific tissue.

Any tissue-specific or tissue-preferred promoter can be utilized in the instant invention. Exemplary tissue-specific or tissue-preferred promoters include, but are not limited to, a root-preferred promoter such as that from the phaseolin gene (Murai, et al., *Science*, 23:476-482 (1983); Sengupta-Gopalan, et al., *Proc. Natl. Acad. Sci. USA*, 82:3320-3324 (1985)); a leaf-specific and light-induced promoter such as that from cab or rubisco (Simpson, et al., *EMBO J.*, 4(11):2723-2729 (1985); Timko, et al., *Nature*, 318:579-582

(1985)); an anther-specific promoter such as that from LAT52 (Twell, et al., *Mol. Gen. Genetics*, 217:240-245 (1989)); a pollen-specific promoter such as that from Zm13 (Guerrero, et al., *Mol. Gen. Genetics*, 244:161-168 (1993)); or a microspore-preferred promoter such as that from apg (Twell, et al., *Sex. Plant Reprod.*, 6:217-224 (1993)).

Signal Sequences for Targeting Proteins to Subcellular Compartments

Transport of a protein produced by transgenes to a subcellular compartment, such as the chloroplast, vacuole, peroxisome, glyoxysome, cell wall, or mitochondrion, or for secretion into the apoplast, is accomplished by means of operably linking the nucleotide sequence encoding a signal sequence to the 5' and/or 3' region of a gene encoding the protein of interest. Targeting sequences at the 5' and/or 3' end of the structural gene may determine during protein synthesis and processing where the encoded protein is ultimately compartmentalized.

The presence of a signal sequence directs a polypeptide to either an intracellular organelle or subcellular compartment or for secretion to the apoplast. Many signal sequences are known in the art. See, for example, Becker, et al., *Plant Mol. Biol.*, 20:49 (1992); Knox, C., et al., *Plant Mol. Biol.*, 9:3-17 (1987); Lerner, et al., *Plant Physiol.*, 91:124-129 (1989); Frontes, et al., *Plant Cell*, 3:483-496 (1991); Matsuoka, et al., *Proc. Natl. Acad. Sci.*, 88:834 (1991); Gould, et al., *J. Cell. Biol.*, 108:1657 (1989); Creissen, et al., *Plant J.*, 2:129 (1991); Kalderon, et al., *Cell*, 39:499-509 (1984); Steifel, et al., *Plant Cell*, 2:785-793 (1990).

Foreign Protein Genes and Ornamental Plant Genes: Transformation

With transgenic plants according to one embodiment of the present invention, a foreign protein can be produced in commercial quantities. Thus, techniques for the selection and propagation of transformed plants, which are well understood in the art, yield a plurality of transgenic plants which are harvested in a conventional manner, and a foreign protein can then be extracted from a tissue of interest or from total biomass. Protein extraction from plant biomass can be accomplished by known methods which are discussed, for example, by Heney and Orr, *Anal. Biochem.*, 114:92-6 (1981).

According to a preferred embodiment, the transgenic plant provided for commercial production of foreign protein is a *Zantedeschia* plant. In another preferred embodiment, the biomass of interest is seed. For the relatively small number of transgenic plants that show higher levels of expression, a genetic map can be generated, primarily via conventional RFLP, PCR, and SSR analysis, which identifies the approximate chromosomal location of the integrated DNA molecule. For exemplary methodologies in this regard, see, Glick and Thompson, *Methods in Plant Molecular Biology and Biotechnology*, CRC Press, Inc., Boca Raton, 269:284 (1993). Map information concerning chromosomal location is useful for proprietary protection of a subject transgenic plant.

Wang, et al. discuss "Large Scale Identification, Mapping and Genotyping of Single-Nucleotide Polymorphisms in the Human Genome," *Science*, 280:1077-1082 (1998), and similar capabilities are becoming increasingly available for the *Zantedeschia* genome. Map information concerning chromosomal location is useful for proprietary protection of a subject transgenic plant. If unauthorized propagation is undertaken and crosses made with other germplasm, the map of the integration region can be compared to similar maps for suspect plants to determine if the latter have a common parentage with the subject plant. Map comparisons would involve hybridizations, RFLP, PCR, SSR, and sequencing, all of

which are conventional techniques. SNPs may also be used alone or in combination with other techniques.

Likewise, by means of one embodiment of the present invention, plants can be genetically engineered to express various phenotypes of commercial interest. Through the transformation of *Zantedeschia*, the expression of genes can be altered to enhance disease resistance, insect resistance, herbicide resistance, ornamental features, and other traits. Transformation can also be used to insert DNA sequences which control or help control male-sterility. DNA sequences native to *Zantedeschia*, as well as non-native DNA sequences, can be transformed into *Zantedeschia* and used to alter levels of native or non-native proteins. Various promoters, targeting sequences, enhancing sequences, and other DNA sequences can be inserted into the genome for the purpose of altering the expression of proteins. The interruption or suppression of the expression of a gene at the level of transcription or translation (also known as gene silencing or gene suppression) is desirable for several aspects of genetic engineering in plants.

Many techniques for gene silencing are well-known to one of skill in the art, including, but not limited to, knock-outs (such as by insertion of a transposable element such as Mu (Vicki Chandler, *The Maize Handbook*, Ch. 118 (Springer-Verlag 1994)) or other genetic elements such as a FRT, Lox, or other site specific integration sites; antisense technology (see, e.g., Sheehy, et al., *PNAS USA*, 85:8805-8809 (1988) and U.S. Pat. Nos. 5,107,065, 5,453,566, and 5,759,829); co-suppression (e.g., Taylor, *Plant Cell*, 9:1245 (1997); Jorgensen, *Trends Biotech.*, 8(12):340-344 (1990); Flavell, *PNAS USA*, 91:3490-3496 (1994); Finnegan, et al., *Bio/Technology*, 12:883-888 (1994); Neuhuber, et al., *Mol. Gen. Genet.*, 244:230-241 (1994)); RNA interference (Napoli, et al., *Plant Cell*, 2:279-289 (1990); U.S. Pat. No. 5,034,323; Sharp, *Genes Dev.*, 13:139-141 (1999); Zamore, et al., *Cell*, 101:25-33 (2000); Montgomery, et al., *PNAS USA*, 95:15502-15507 (1998)), virus-induced gene silencing (Burton, et al., *Plant Cell*, 12:691-705 (2000); Baulcombe, *Curr. Op. Plant Bio.*, 2:109-113 (1999)); target-RNA-specific ribozymes (Haseloff, et al., *Nature*, 334:585-591 (1988)); hairpin structures (Smith, et al., *Nature*, 407:319-320 (2000); U.S. Pat. Nos. 6,423,885, 7,138,565, 6,753,139, and 7,713,715); MicroRNA (Aukerman & Sakai, *Plant Cell*, 15:2730-2741 (2003)); ribozymes (Steinecke, et al., *EMBO J.*, 11:1525 (1992); Perriman, et al., *Antisense Res. Dev.*, 3:253 (1993)); oligonucleotide mediated targeted modification (e.g., U.S. Pat. Nos. 6,528,700 and 6,911,575); Zn-finger targeted molecules (e.g., U.S. Pat. Nos. 7,151,201, 6,453,242, 6,785,613, 7,177,766 and 7,788,044); and other methods or combinations of the above methods known to those of skill in the art.

Methods for *Zantedeschia* Transformation

Numerous methods for plant transformation have been developed including biological and physical plant transformation protocols. See, for example, Miki, et al., "Procedures for Introducing Foreign DNA into Plants," in *Methods in Plant Molecular Biology and Biotechnology*, Glick and Thompson Eds., CRC Press, Inc., Boca Raton, pp. 67-88 (1993). In addition, expression vectors and in-vitro culture methods for plant cell or tissue transformation and regeneration of plants are available. See, for example, Gruber, et al., "Vectors for Plant Transformation," in *Methods in Plant Molecular Biology and Biotechnology*, Glick and Thompson Eds., CRC Press, Inc., Boca Raton, pp. 89-119 (1993).

A. *Agrobacterium*-mediated Transformation: One method for introducing an expression vector into plants is based on the natural transformation system of *Agrobacterium*. See, for

example, Horsch, et al., *Science*, 227:1229 (1985). *A. tumefaciens* and *A. rhizogenes* are plant pathogenic soil bacteria which genetically transform plant cells. The Ti and Ri plasmids of *A. tumefaciens* and *A. rhizogenes*, respectively, carry genes responsible for genetic transformation of the plant. See, for example, Kado, C. I., *Crit. Rev. Plant Sci.*, 10:1 (1991). Descriptions of *Agrobacterium* vector systems and methods for *Agrobacterium*-mediated gene transfer are provided by Gruber, et al., supra, Miki, et al., supra, and Moloney, et al., *Plant Cell Reports*, 8:238 (1989). See also, U.S. Pat. No. 5,563,055 (Townsend and Thomas), issued Oct. 8, 1996.

B. Direct Gene Transfer: Several methods of plant transformation, collectively referred to as direct gene transfer, have been developed as an alternative to *Agrobacterium*-mediated transformation. A generally applicable method of plant transformation is microprojectile-mediated transformation where DNA is carried on the surface of microprojectiles measuring 1 to 4 μ m. The expression vector is introduced into plant tissues with a biolistic device that accelerates the microprojectiles to speeds of 300 to 600 m/s which is sufficient to penetrate plant cell walls and membranes. Sanford, et al., *Part. Sci. Technol.*, 5:27 (1987); Sanford, J. C., *Trends Biotech.*, 6:299 (1988); Klein, et al., *Bio/Tech.*, 6:559-563 (1988); Sanford, J. C., *Physiol Plant*, 7:206 (1990); Klein, et al., *Biotechnology*, 10:268 (1992). See also, U.S. Pat. No. 5,015,580 (Christou, et al.), issued May 14, 1991 and U.S. Pat. No. 5,322,783.

Another method for physical delivery of DNA to plants is sonication of target cells. Zhang, et al., *Bio/Technology*, 9:996 (1991). Alternatively, liposome and spheroplast fusion have been used to introduce expression vectors into plants. Deshayes, et al., *EMBO J.*, 4:2731 (1985); Christou, et al., *Proc Natl. Acad. Sci. USA*, 84:3962 (1987). Direct uptake of DNA into protoplasts using CaCl_2 precipitation, polyvinyl alcohol or poly-L-ornithine have also been reported. Hain, et al., *Mol. Gen. Genet.*, 199:161 (1985) and Draper, et al., *Plant Cell Physiol.*, 23:451 (1982). Electroporation of protoplasts and whole cells and tissues has also been described (D'Halluin, et al., *Plant Cell*, 4:1495-1505 (1992); and Spencer, et al., *Plant Mol. Biol.*, 24:51-61 (1994)).

Following transformation of *Zantedeschia* target tissues, expression of the above-described selectable marker genes allows for preferential selection of transformed cells, tissues, and/or plants, using regeneration and selection methods well-known in the art.

The foregoing methods for transformation would typically be used for producing a transgenic variety. The transgenic variety could then be crossed with another (non-transformed or transformed) variety in order to produce a new transgenic variety. Alternatively, a genetic trait that has been engineered into a particular *Zantedeschia* plant using the foregoing transformation techniques could be moved into another line using traditional backcrossing techniques that are well-known in the plant breeding arts. For example, a backcrossing approach could be used to move an engineered trait from a public, non-elite variety into an elite variety, or from a variety containing a foreign gene in its genome into a variety or varieties that do not contain that gene. As used herein, "crossing" can refer to a simple x by y cross or the process of backcrossing depending on the context.

Likewise, by means of one embodiment of the present invention, commercially important genes can be expressed in transformed plants. More particularly, plants can be genetically engineered to express various phenotypes of commercial interest. Exemplary genes implicated in this regard include, but are not limited to, those categorized below:

1. Genes that Confer Resistance to Pests or Disease and that Encode:

A. Plant disease resistance genes. Plant defenses are often activated by specific interaction between the product of a disease resistance gene (R) in the plant and the product of a corresponding avirulence (Avr) gene in the pathogen. A plant variety can be transformed with one or more cloned resistance genes to engineer plants that are resistant to specific pathogen strains. See, for example, Jones, et al., *Science*, 266:789 (1994) (cloning of the tomato Cf-9 gene for resistance to *Cladosporium fulvum*); Martin, et al., *Science*, 262:1432 (1993) (tomato Pto gene for resistance to *Pseudomonas syringae* pv. tomato encodes a protein kinase); Mindrinos, et al., *Cell*, 78:1089 (1994) (*Arabidopsis* RSP2 gene for resistance to *Pseudomonas syringae*); McDowell & Woffenden, *Trends Biotechnol.*, 21(4):178-83 (2003); and Toyoda, et al., *Transgenic Res.*, 11 (6):567-82 (2002).

B. A gene conferring resistance to a pest for spotted wilt or Dasheen mosaic virus.

C. A *Bacillus thuringiensis* protein, a derivative thereof or a synthetic polypeptide modeled thereon. See, for example, Geiser, et al., *Gene*, 48:109 (1986), who disclose the cloning and nucleotide sequence of a Bt δ -endotoxin gene. Moreover, DNA molecules encoding δ -endotoxin genes can be purchased from American Type Culture Collection, Manassas, Va., for example, under ATCC Accession Nos. 40098, 67136, 31995, and 31998.

D. A vitamin-binding protein such as avidin. See, International Application No. PCT/US 1993/006487, which teaches the use of avidin and avidin homologues as larvicides against insect pests.

E. An enzyme inhibitor, for example, a protease or proteinase inhibitor or an amylase inhibitor. See, for example, Abe, et al., *J. Biol. Chem.*, 262:16793 (1987) (nucleotide sequence of rice cysteine proteinase inhibitor); Huub, et al., *Plant Molec. Biol.*, 21:985 (1993) (nucleotide sequence of cDNA encoding tobacco proteinase inhibitor I); Sumitani, et al., *Biosci. Biotech. Biochem.*, 57:1243 (1993) (nucleotide sequence of *Streptomyces nitrosporeus* α -amylase inhibitor); and U.S. Pat. No. 5,494,813.

F. An insect-specific hormone or pheromone, such as an ecdysteroid or juvenile hormone, a variant thereof, a mimetic based thereon, or an antagonist or agonist thereof. See, for example, the disclosure by Hammock, et al., *Nature*, 344:458 (1990), of baculovirus expression of cloned juvenile hormone esterase, an inactivator of juvenile hormone.

G. An insect-specific peptide or neuropeptide which, upon expression, disrupts the physiology of the affected pest. For example, see the disclosures of Regan, *J. Biol. Chem.*, 269:9 (1994) (expression cloning yields DNA coding for insect diuretic hormone receptor); Pratt, et al., *Biochem. Biophys. Res. Comm.*, 163:1243 (1989) (an allostatin is identified in *Diploptera puntata*); Chattopadhyay, et al., *Critical Reviews in Microbiology*, 30(1):33-54 (2004); Zjawiony, J. Nat. Prod., 67(2):300-310 (2004); Carlini & Grossi-de-Sa, *Toxicon*, 40(11):1515-1539 (2002); Ussuf, et al., *Curr Sci.*, 80(7):847-853 (2001); Vasconcelos & Oliveira, *Toxicon*, 44(4):385-403 (2004). See also, U.S. Pat. No. 5,266,317 which discloses genes encoding insect-specific, paralytic neurotoxins.

H. An insect-specific venom produced in nature by a snake, a wasp, etc. For example, see, Pang, et al., *Gene*, 116:165 (1992), for disclosure of heterologous expression in plants of a gene coding for a scorpion insectotoxic peptide.

I. An enzyme responsible for a hyperaccumulation of a monoterpene, a sesquiterpene, a steroid, hydroxamic acid, a phenylpropanoid derivative, or another non-protein molecule with insecticidal activity.

J. An enzyme involved in the modification, including the post-translational modification, of a biologically active molecule; for example, a glycolytic enzyme, a proteolytic enzyme, a lipolytic enzyme, a nuclease, a cyclase, a transaminase, an esterase, a hydrolase, a phosphatase, a kinase, a phosphorylase, a polymerase, an elastase, a chitinase, and a glucanase, whether natural or synthetic. See, U.S. Pat. No. 5,955,653 which discloses the nucleotide sequence of a calase gene. DNA molecules which contain chitinase-encoding sequences can be obtained, for example, from the ATCC under Accession Nos. 39637 and 67152. See also, Kramer, et al., *Insect Biochem. Molec. Biol.*, 23:691 (1993), who teach the nucleotide sequence of a cDNA encoding tobacco hornworm chitinase, and Kawalleck, et al., *Plant Molec. Biol.*, 21:673 (1993), who provide the nucleotide sequence of the parsley ubi4-2 polyubiquitin gene, U.S. Pat. Nos. 7,145,060, 7,087,810, and 6,563,020.

K. A molecule that stimulates signal transduction. For example, see the disclosure by Botella, et al., *Plant Molec. Biol.*, 24:757 (1994), of nucleotide sequences for mung bean calmodulin cDNA clones, and Griess, et al., *Plant Physiol.*, 104:1467 (1994), who provide the nucleotide sequence of a maize calmodulin cDNA clone.

L. A hydrophobic moment peptide. See, U.S. Pat. No. 5,580,852, which discloses peptide derivatives of tachyplesin which inhibit fungal plant pathogens, and U.S. Pat. No. 5,607,914 which teaches synthetic antimicrobial peptides that confer disease resistance.

M. A membrane permease, a channel former or a channel blocker. For example, see the disclosure of Jaynes, et al., *Plant Sci.*, 89:43 (1993), of heterologous expression of a cecropin-13 lytic peptide analog to render transgenic tobacco plants resistant to *Pseudomonas solanacearum*.

N. A viral-invasive protein or a complex toxin derived therefrom. For example, the accumulation of viral coat proteins in transformed plant cells imparts resistance to viral infection and/or disease development effected by the virus from which the coat protein gene is derived, as well as by related viruses. See, Beachy, et al., *Ann. Rev. Phytopathol.*, 28:451 (1990). Coat protein-mediated resistance has been conferred upon transformed plants against alfalfa mosaic virus, cucumber mosaic virus, and tobacco mosaic virus.

O. An insect-specific antibody or an immunotoxin derived therefrom. Thus, an antibody targeted to a critical metabolic function in the insect gut would inactivate an affected enzyme, killing the insect.

P. A virus-specific antibody. See, for example, Tavladoraki, et al., *Nature*, 366:469 (1993), who show that transgenic plants expressing recombinant antibody genes are protected from virus attack.

Q. A developmental-arrestive protein produced in nature by a pathogen or a parasite. Thus, fungal endo- α -1,4-D-polygalacturonases facilitate fungal colonization and plant nutrient release by solubilizing plant cell wall homo- α -1,4-D-galacturonase. See, Lamb, et al., *Bio/Technology*, 10:1436 (1992). The cloning and characterization of a gene which encodes a bean endopolygalacturonase-inhibiting protein is described by Toubart, et al., *Plant J.*, 2:367 (1992).

R. A developmental-arrestive protein produced in nature by a plant. For example, Logemann, et al., *Bio/Technology*, 10:305 (1992), have shown that transgenic plants expressing the barley ribosome-inactivating gene have an increased resistance to fungal disease.

R. Genes involved in the Systemic Acquired Resistance (SAR) Response and/or the pathogenesis-related genes. Briggs, S., *Current Biology*, 5(2) (1995); Pieterse & Van

Loon, *Curr. Opin. Plant Bio.*, 7(4):456-64 (2004); and Somsich, *Cell*, 113(7):815-6 (2003).

S. Antifungal genes. See, Cornelissen and Melchers, *Plant Physiol.*, 101:709-712 (1993); Parijs, et al., *Planta*, 183:258-264 (1991); and Bushnell, et al., *Can. J. of Plant Path.*, 20(2): 137-149 (1998). See also, U.S. Pat. No. 6,875,907.

T. Detoxification genes, such as for fumonisin, beauvericin, moniliformin, and zearalenone and their structurally-related derivatives. See, U.S. Pat. No. 5,792,931.

U. Cystatin and cysteine proteinase inhibitors. See, U.S. Pat. No. 7,205,453.

V. Genes that confer resistance to *Phytophthora* Root Rot, such as the Rps 1, Rps 1-a, Rps 1-b, Rps 1-c, Rps 1-d, Rps 1-e, Rps 1-k, Rps 2, Rps 3-a, Rps 3-b, Rps 3-c, Rps 4, Rps 5, Rps 6, Rps 7, and other Rps genes.

W. Genes that confer resistance to *Pythium* root rot and crown rot. See for example, Tanyolac, Bahattin, et al., *African J. of Biotech.* 9(19):2727-2730 (2011) and Nzungize, J., et al., *African J. of Biotech.* 5(3):193-200 (2011).

Any of the above-listed disease or pest resistance genes (A-W) can be introduced into *Zantedeschia* variety GSC-CCAFI through a variety of means including, but not limited to, transformation and crossing.

2. Genes that Confer Resistance to an Herbicide, for Example:

A. An herbicide that inhibits the growing point or meristem, such as an imidazolinone or a sulfonylurea. Exemplary genes in this category code for mutant ALS and AHAS enzyme as described, for example, by Lee, et al., *EMBO J.*, 7:1241 (1988) and Mild, et al., *Theor. Appl. Genet.*, 80:449 (1990), respectively.

B. Glyphosate (resistance conferred by mutant 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) and aroA genes, respectively) and other phosphono compounds, such as glufosinate (phosphinothricin acetyl transferase (PAT) and *Streptomyces hygroscopicus* PAT bar genes), pyridinoxy or phenoxy propionic acids, and cyclohexanediones (ACCase inhibitor-encoding genes). See, for example, U.S. Pat. No. 4,940,835 which discloses the nucleotide sequence of a form of EPSPS which can confer glyphosate resistance. U.S. Pat. No. 5,627,061 which describes genes encoding EPSPS enzymes. See also, U.S. Pat. Nos. 6,566,587, 6,338,961, 6,248,876, 6,040,497, 5,804,425, 5,633,435, 5,145,783, 4,971,908, 5,312,910, 5,188,642, 4,940,835, 5,866,775, 6,225,114, 6,130,366, 5,310,667, 4,535,060, 4,769,061, 5,633,448, 5,510,471, 6,803,501, RE 36,449, RE 37,287, and 5,491,288, which are incorporated herein by reference for this purpose. Glyphosate resistance is also imparted to plants that express a gene that encodes a glyphosate oxido-reductase enzyme, as described more fully in U.S. Pat. Nos. 5,776,760 and 5,463,175, which are incorporated herein by reference for this purpose. In addition, glyphosate resistance can be imparted to plants by the over expression of genes encoding glyphosate N-acetyltransferase. See, for example, U.S. Pat. No. 7,462,481. A DNA molecule encoding a mutant aroA gene can be obtained under ATCC Accession No. 39256, and the nucleotide sequence of the mutant gene is disclosed in U.S. Pat. No. 4,769,061. European Patent Appl. No. 0333033 and U.S. Pat. No. 4,975,374 disclose nucleotide sequences of glutamine synthetase genes which confer resistance to herbicides such as L-phosphinothricin. The nucleotide sequence of a PAT gene is provided in European Patent No. 0242246 to Leemans, et al. DeGreef, et al., *Bio/Technology*, 7:61 (1989) describe the production of transgenic plants that express chimeric bar genes coding for phosphinothricin acetyl transferase activity. Exemplary of genes conferring resistance to phenoxy propionic acids and cyclohexones, such as sethoxy-

dim and haloxyfop are the Acc1-S1, Acc1-S2, and Acc2-S3 genes described by Marshall, et al., *Theor. Appl. Genet.*, 83:435 (1992).

C. An herbicide that inhibits photosynthesis, such as a triazine (psbA and gs+ genes) and a benzonitrile (nitrilase gene). Przibila, et al., *Plant Cell*, 3:169 (1991), describe the transformation of *Chlamydomonas* with plasmids encoding mutant psbA genes. Nucleotide sequences for nitrilase genes are disclosed in U.S. Pat. No. 4,810,648 to Stalker and DNA molecules containing these genes are available under ATCC Accession Nos. 53435, 67441, and 67442. Cloning and expression of DNA coding for a glutathione S-transferase is described by Hayes, et al., *Biochem. J.*, 285:173 (1992).

D. Acetohydroxy acid synthase, which has been found to make plants that express this enzyme resistant to multiple types of herbicides, has been introduced into a variety of plants. See, Hattori, et al., *Mol. Gen. Genet.*, 246:419 (1995). Other genes that confer tolerance to herbicides include a gene encoding a chimeric protein of rat cytochrome P4507A1 and yeast NADPH-cytochrome P450 oxidoreductase (Shiota, et al., *Plant Physiol.*, 106:17 (1994)); genes for glutathione reductase and superoxide dismutase (Aono, et al., *Plant Cell Physiol.*, 36:1687 (1995)); and genes for various phosphotransferases (Datta, et al., *Plant Mol. Biol.*, 20:619 (1992)).

E. Protoporphyrinogen oxidase (protoph) is necessary for the production of chlorophyll, which is necessary for all plant survival. The protoph enzyme serves as the target for a variety of herbicidal compounds. These herbicides also inhibit growth of all the different species of plants present, causing their total destruction. The development of plants containing altered protoph activity which are resistant to these herbicides are described in U.S. Pat. Nos. 6,288,306, 6,282,837, 5,767,373, and 6,084,155.

Any of the above listed herbicide genes (A-E) can be introduced into the claimed *Zantedeschia* variety through a variety of means including but not limited to transformation and crossing.

3. Genes that Control Male Sterility:

There are several methods of conferring genetic male sterility available, such as multiple mutant genes at separate locations within the genome that confer male sterility, as disclosed in U.S. Pat. Nos. 4,654,465 and 4,727,219 to Brar, et al., and chromosomal translocations as described by Patterson in U.S. Pat. Nos. 3,861,709 and 3,710,511. In addition to these methods, Albertsen, et al., U.S. Pat. No. 5,432,068, describes a system of nuclear male sterility which includes: identifying a gene which is critical to male fertility; silencing this native gene which is critical to male fertility; removing the native promoter from the essential male fertility gene and replacing it with an inducible promoter; inserting this genetically engineered gene back into the plant; and thus creating a plant that is male sterile because the inducible promoter is not "on" resulting in the male fertility gene not being transcribed. Fertility is restored by inducing, or turning "on," the promoter, which in turn allows the gene that confers male fertility to be transcribed.

A. Introduction of a deacetylase gene under the control of a tapetum-specific promoter and with the application of the chemical N-Ac-PPT. See, U.S. Pat. No. 6,384,304.

B. Introduction of various stamen-specific promoters. See, U.S. Pat. Nos. 5,639,948 and 5,589,610.

C. Introduction of the barnase and the barstar genes. See, Paul, et al., *Plant Mol. Biol.*, 19:611-622 (1992).

For additional examples of nuclear male and female sterility systems and genes, see also, U.S. Pat. Nos. 5,859,341, 6,297,426, 5,478,369, 5,824,524, 5,850,014, and 6,265,640, all of which are hereby incorporated by reference.

4. Genes that Create a Site for Site Specific DNA Integration:

This includes the introduction of FRT sites that may be used in the FLP/FRT system and/or Lox sites that may be used in the Cre/Lox system. See, for example, Lyznik, et al., Site-Specific Recombination for Genetic Engineering in Plants, *Plant Cell Rep.*, 21:925-932 (2003) and U.S. Pat. No. 6,187,994, which are hereby incorporated by reference. Other systems that may be used include the Gin recombinase of phage Mu (Maeser, et al. (1991)); the Pin recombinase of *E. coli* (Enomoto, et al. (1983)); and the R/R system of the pSRi plasmid (Araki, et al. (1992)).

5. Genes that Affect Abiotic Stress Resistance:

Genes that affect abiotic stress resistance (including but not limited to flowering, seed development, enhancement of nitrogen utilization efficiency, altered nitrogen responsiveness, drought resistance or tolerance, cold resistance or tolerance, and salt resistance or tolerance). For example, see U.S. Pat. No. 6,653,535 where water use efficiency is altered through alteration of malate; U.S. Pat. Nos. 5,892,009, 5,965,705, 5,929,305, 5,891,859, 6,417,428, 6,664,446, 6,706,866, 6,717,034, 6,801,104, 6,946,586, 7,238,860, 7,635,800, 7,135,616, 7,193,129, and 7,601,893; and International Publ. Nos. WO 2001/026459, WO 2001/035725, WO 2001/035727, WO 2001/036444, WO 2001/036597, WO 2001/036598, WO 2002/015675, and WO 2002/077185, describing genes, including CBF genes and transcription factors effective in mitigating the negative effects of freezing, high salinity, and drought on plants, as well as conferring other positive effects on plant phenotype; U.S. Publ. No. 2004/0148654, where abscisic acid is altered in plants resulting in improved plant phenotype, such as increased tolerance to abiotic stress; U.S. Pat. Nos. 6,992,237, 6,429,003, 7,049,115, and 7,262,038, where cytokinin expression is modified resulting in plants with increased stress tolerance, such as drought tolerance. See also, WO 02/02776, WO 2003/052063, JP 2002281975, U.S. Pat. No. 6,084,153, WO 01/64898, and U.S. Pat. Nos. 6,177,275 and 6,107,547 (enhancement of nitrogen utilization and altered nitrogen responsiveness). For ethylene alteration, see, U.S. Publ. Nos. 2004/0128719, 2003/0166197, and U.S. application Ser. No. 09/856,834. For plant transcription factors or transcriptional regulators of abiotic stress, see, e.g., U.S. Publ. Nos. 2004/0098764 or 2004/0078852.

Other genes and transcription factors that affect plant growth and commercial traits, such as flowering, plant growth, and/or plant structure, can be introduced or introgressed into plants. See for example, U.S. Pat. Nos. 6,140,085, and 6,265,637 (CO); U.S. Pat. No. 6,670,526 (ESD4); U.S. Pat. Nos. 6,573,430 and 7,157,279 (TFL); U.S. Pat. No. 6,713,663 (FT); U.S. Pat. Nos. 6,794,560, 6,307,126 (GAD); U.S. Pat. No. 7,045,682 (VRN1); U.S. Pat. Nos. 6,949,694 and 7,253,274 (VRN2); U.S. Pat. No. 6,887,708 (GI); U.S. Pat. No. 7,320,158 (FRI); U.S. Pat. No. 6,307,126 (GAD); U.S. Pat. Nos. 6,762,348 and 7,268,272 (D8 and Rht); and U.S. Pat. Nos. 7,345,217, 7,511,190, 7,659,446, and 7,825,296 (transcription factors).

Genetic Marker Profile Through SSR and First Generation Progeny

In addition to phenotypic observations, a plant can also be identified by its genotype. The genotype of a plant can be characterized through a genetic marker profile which can identify plants of the same variety, or a related variety, or be used to determine or validate a pedigree. Genetic marker profiles can be obtained by techniques such as Restriction Fragment Length Polymorphisms (RFLPs), Randomly Amplified Polymorphic DNAs (RAPDs), Arbitrarily Primed Polymerase Chain Reaction (AP-PCR), DNA Amplification

Fingerprinting (DAF), Sequence Characterized Amplified Regions (SCARs), Amplified Fragment Length Polymorphisms (AFLPs), Simple Sequence Repeats (SSRs) (which are also referred to as Microsatellites), and Single Nucleotide Polymorphisms (SNPs). For example, see, Berry, et al., "Assessing Probability of Ancestry Using Simple Sequence Repeat Profiles: Applications to Maize Inbred Lines and Soybean Varieties," *Genetics*, 165:331-342 (2003), each of which are incorporated by reference herein in their entirety.

Particular markers used for these purposes are not limited to any particular set of markers, but are envisioned to include any type of marker and marker profile which provides a means of distinguishing varieties. One method of comparison is to use only homozygous loci for *Zantedeschia* variety GSCCCAFI.

Primers and PCR protocols for assaying these and other markers are well-known. In addition to being used for identification of *Zantedeschia* variety GSCCCAFI, and plant parts and plant cells of *Zantedeschia* variety GSCCCAFI, the genetic profile may be used to identify a *Zantedeschia* plant produced through the use of *Zantedeschia* variety GSCCCAFI or to verify a pedigree for progeny plants produced through the use of *Zantedeschia* variety GSCCCAFI. The genetic marker profile is also useful in breeding and developing backcross conversions.

One embodiment of the present invention comprises a *Zantedeschia* plant characterized by molecular and physiological data obtained from the representative sample of said variety deposited with the American Type Culture Collection (ATCC) or with the National Collections of Industrial, Food and Marine Bacteria (NCIMB). Further provided by another embodiment of the invention is a *Zantedeschia* plant formed by the combination of the disclosed *Zantedeschia* plant or plant cell with another *Zantedeschia* plant or cell and comprising the homozygous alleles of the variety. "Cell" as used herein includes a plant cell, whether isolated, in tissue culture or incorporated in a plant or plant part.

Means of performing genetic marker profiles using SSR polymorphisms are well-known in the art. SSRs are genetic markers based on polymorphisms in repeated nucleotide sequences, such as microsatellites. A marker system based on SSRs can be highly informative in linkage analysis relative to other marker systems in that multiple alleles may be present ("linkage" refers to a phenomenon wherein alleles on the same chromosome tend to segregate together more often than expected by chance if their transmission was independent). Another advantage of this type of marker is that, through use of flanking primers, detection of SSRs can be achieved, for example, by the polymerase chain reaction (PCR), thereby eliminating the need for labor-intensive Southern hybridization. The PCR detection is done by use of two oligonucleotide primers flanking the polymorphic segment of repetitive DNA. Repeated cycles of heat denaturation of the DNA followed by annealing of the primers to their complementary sequences at low temperatures, and extension of the annealed primers with DNA polymerase, comprise the major part of the methodology.

Following amplification, markers can be scored by electrophoresis of the amplification products. Scoring of marker genotype is based on the size of the amplified fragment, which may be measured by the number of base pairs of the fragment. While variation in the primer used or in laboratory procedures can affect the reported fragment size, relative values should remain constant regardless of the specific primer or laboratory used. When comparing varieties it is preferable if all SSR profiles are performed in the same lab. Primers used are publicly available and well-known.

The SSR profile of a *Zantedeschia* plant GSCCCAFI can be used to identify plants comprising *Zantedeschia* variety GSCCCAFI as a parent, since such plants will comprise the same homozygous alleles as *Zantedeschia* variety GSCCCAFI. Because the *Zantedeschia* variety is essentially homozygous at all relevant loci, most loci should have only one type of allele present. In contrast, a genetic marker profile of an F_1 progeny should be the sum of those parents, e.g., if one parent was homozygous for allele x at a particular locus, and the other parent homozygous for allele y at that locus, then the F_1 progeny will be xy (heterozygous) at that locus. Subsequent generations of progeny produced by selection and breeding are expected to be of genotype x (homozygous), y (homozygous), or xy (heterozygous) for that locus position. When the F_1 plant is selfed or sibbed for successive filial generations, the locus should be either x or y for that position.

In addition, plants and plant parts substantially benefiting from the use of *Zantedeschia* variety GSCCCAFI in their development, such as *Zantedeschia* variety GSCCCAFI comprising a backcross conversion, transgene, or genetic sterility factor, may be identified by having a molecular marker profile with a high percent identity to *Zantedeschia* variety GSCCCAFI. Such a percent identity might be 95%, 96%, 97%, 98%, 99%, 99.5%, or 99.9% identical to *Zantedeschia* variety GSCCCAFI. Percent identity refers to the comparison of the homozygous alleles of two *Zantedeschia* varieties. Percent identity or percent similarity is determined by comparing a statistically significant number of the homozygous alleles of two developed varieties. For example, a percent identity of 90% between *Zantedeschia* variety 1 and *Zantedeschia* variety 2 means that the two varieties have the same allele at 90% of their loci.

The SSR profile of *Zantedeschia* variety GSCCCAFI can also be used to identify essentially derived varieties and other progeny varieties developed from the use of *Zantedeschia* variety GSCCCAFI, as well as cells and other plant parts thereof. Such plants may be developed using the markers, for example, identified in U.S. Pat. Nos. 6,162,967, and 7,288,386. Progeny plants and plant parts produced using *Zantedeschia* variety GSCCCAFI may be identified by having a molecular marker profile of at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 99.5% genetic contribution from *Zantedeschia* variety, as measured by either percent identity or percent similarity. Such progeny may be further characterized as being within a pedigree distance of *Zantedeschia* variety GSCCCAFI, such as within 1, 2, 3, 4, or 5 or less cross-pollinations to a *Zantedeschia* plant other than *Zantedeschia* GSCCCAFI or a plant that has *Zantedeschia* variety GSCCCAFI as a progenitor. Unique molecular profiles may be identified with other molecular tools such as SNPs and RFLPs.

While determining the SSR genetic marker profile of the plants described supra, several unique SSR profiles may also be identified which did not appear in either parent of such plant. Such unique SSR profiles may arise during the breeding process from recombination or mutation. A combination of several unique alleles provides a means of identifying a plant variety, an F_1 progeny produced from such variety, and progeny produced from such variety.

Tissue Culture

Further reproduction of the variety can occur by tissue culture and regeneration. Tissue culture of various tissues of ornamental plants and *Zantedeschia* and regeneration of plants therefrom is well-known and widely published. For example, reference may be had to do Valla Rego, Luciana et

al., *Crop Breeding and Applied Technology*, 1(3): 283-300 (2001); Komatsuda, T., et al., *Crop Sci.*, 31:333-337 (1991); Stephens, P. A., et al., *Theor. Appl. Genet.*, 82:633-635 (1991); Komatsuda, T., et al., *Plant Cell, Tissue and Organ Culture*, 28:103-113 (1992); Dhir, S., et al., *Plant Cell Reports*, 11:285-289 (1992); Pandey, P., et al., *Japan J. Breed.*, 42:1-5 (1992); and Shetty, K., et al., *Plant Science*, 81:245-251 (1992). Thus, another aspect of this invention is to provide cells which upon growth and differentiation produce *Zantedeschia* plants having the physiological and morphological characteristics of *Zantedeschia* variety GSC-CCAFI.

Regeneration refers to the development of a plant from tissue culture. The term "tissue culture" indicates a composition comprising isolated cells of the same or a different type or a collection of such cells organized into parts of a plant. Exemplary types of tissue cultures are protoplasts, calli, plant clumps, and plant cells that can generate tissue culture that are intact in plants or parts of plants, such as pollen, ovules, embryos, protoplasts, meristematic cells, callus, pollen, leaves, ovules, anthers, cotyledons, hypocotyl, pistils, roots, root tips, spathe, spadix, seeds, petiole, rhizome, pods, berries, bulb, tuber, shoot, or stems, and the like. Means for preparing and maintaining plant tissue culture are well-known in the art.

While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions, and sub-combinations as are within their true spirit and scope.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

The present invention, in various embodiments, include components, methods, processes, systems and/or apparatus substantially as depicted and described herein, including various embodiments, subcombinations, and subsets thereof. Those of skill in the art will understand how to make and use the present invention after understanding the present disclosure.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the invention are grouped together in one or more embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations and modifications are within the scope of the invention (e.g., as may be

within the skill and knowledge of those in the art, after understanding the present disclosure). It is intended to obtain rights which include alternative embodiments to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or acts to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or acts are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

The use of the terms "a," "an," and "the," and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. For example, if the range 10-15 is disclosed, then 11, 12, 13, and 14 are also disclosed. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

DEPOSIT INFORMATION

A deposit of the Golden State Bulb Growers, Inc. proprietary *Zantedeschia* variety GSCCAFI disclosed above and recited in the appended claims has been made with the National Collections of Industrial, Food and Marine Bacteria (NCIMB), Ferguson Building, Craibstone Estate, Bucksburn, Aberdeen, Scotland, AB21 9YA, United Kingdom. The date of deposit was Jun. 18, 2014. The deposit of 2,500 seeds was taken from the same deposit maintained by Golden State Bulb Growers, Inc. since prior to the filing date of this application. All restrictions upon availability to the public will be irrevocably removed upon granting of a patent in accordance with 37 C.F.R. §1.808(a)(2), and the deposit is intended to meet all of the requirements of 37 C.F.R. §§1.801-1.809. The NCIMB No. is 42240. The deposit will be maintained in the depository for a period of thirty years, or five years after the last request, or for the enforceable life of the patent, whichever is longer, and will be replaced as necessary during the period.

What is claimed is:

1. A seed of *Zantedeschia* variety GSCCAFI, wherein a sample of seed of said variety is deposited under NCIMB No. 42240.
2. A *Zantedeschia* plant, or a part thereof, produced by growing the seed of claim 1.
3. A tissue culture produced from protoplasts or cells from the plant of claim 2, wherein said cells or protoplasts are produced from a plant part selected from the group consisting of embryos, protoplasts, meristematic cells, callus, pollen, leaves, ovules, anthers, cotyledons, hypocotyl, pistils, roots, root tips, spathe, spadix, seeds, petiole, pods, berries, bulb, tuber, shoot, and stems.
4. A *Zantedeschia* plant of variety GSCCAFI regenerated from the tissue culture of claim 3, wherein the regenerated

plant has all the physiological and morphological characteristics of *Zantedeschia* variety GSCCCAFI listed in Table 1.

5. A method for producing a *Zantedeschia* seed, said method comprising crossing two *Zantedeschia* plants and harvesting the resultant *Zantedeschia* seed, wherein at least one *Zantedeschia* plant is the *Zantedeschia* plant of claim 2. 5

6. A method of producing an herbicide resistant *Zantedeschia* plant, wherein said method comprises introducing a transgene conferring herbicide resistance into the plant of claim 2. 10

7. An herbicide resistant *Zantedeschia* plant produced by the method of claim 6.

8. A method of producing a pest or insect resistant *Zantedeschia* plant, wherein said method comprises introducing a transgene conferring pest or insect resistance into the *Zantedeschia* plant of claim 2. 15

9. A pest or insect resistant *Zantedeschia* plant produced by the method of claim 8.

10. The *Zantedeschia* plant of claim 9, wherein the transgene encodes a *Bacillus thuringiensis* (Bt) endotoxin. 20

11. A method of producing a disease resistant *Zantedeschia* plant, wherein said method comprises introducing a transgene which confers disease resistance into the *Zantedeschia* plant of claim 2.

12. A disease resistant *Zantedeschia* plant produced by the method of claim 11. 25

13. A plant of *Zantedeschia* variety GSCCCAFI, wherein a sample of seed of said variety is deposited under NCIMB No. 42240.

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